Power Supply with Improved Cooling

Technical Field

The invention relates to an electrical and/or electronical device, particularly a power supply, including a casing, an electric and/or electronic circuit with a heat generating component and at least one fan, where the heat generating component is in thermal contact with a wall portion of the casing.

Background Art

Over the past years, there has been a rapidly increasing demand for electrically operated devices with an ongoing trend towards devices with smaller dimensions and less weight. These requirements not only apply to the whole devices, but also to each single element of such devices such as for example the electric components like the power supply.

One problem with such devices is that the smaller the electric and/or electronic circuits become, the more waste heat is generated in a given volume and the more heat has to be removed from that given volume.

One possible solution is to add more heat sinks. But in many cases there is not enough space left for additional heat sinks. In a known space-efficient cooling technique the heat generating components such as for example the power semiconductors of a power supply are directly bonded to the casing of the power supply that is made of aluminium. The heat generated by the power semiconductors is transferred to the casing from where it is dissipated into the air.

However, this cooling method has the drawback that the maximum power to be dissipated is very limited.

Summary of the Invention

It is therefore an object of the invention to create an electrical and/or electronical device pertaining to the technical field initially mentioned, that avoids the drawbacks of the prior art and that particularly enables a space-efficient cooling of the device with improved cooling properties.

The solution of the invention is specified by the features of claim 1. According to the invention the electrical and/or electronical device, for example a power supply, an amplifier or the like, includes a casing and an electric and/or electronic circuit. The casing includes a double wall portion with an inner wall portion that is a part of the inner surface

of the casing and an outer wall portion that is a part of the outer surface of the casing. The double wall portion defines an air duct between the inner wall portion and the outer wall portion. The power supply further includes a fan that is arranged such that the air flow produced by the fan, or at least a part of it, is directed through the air duct.

Typically, the circuit includes a plurality of components such as mechanical, electric and/or electronic components. Among other components, the circuit includes one or more heat generating components such as for example an inductive element of a transformer or power semiconductors. The heat generating component is arranged within the casing such that it is in thermal contact with the inner wall portion of the double wall portion of the casing. Therefore, said double wall portion acts as a heat sink for the heat produced by the heat generating component. The heat then is emitted from the casing to the surrounding air and also to the air duct from where it is dissipated by the air flow from the fan.

The heat generating component does not have to be in direct physical contact with the inner wall portion. The thermal contact between the heat generating component and the inner wall portion of the casing could also be established via a heat conducting adapter, such as for example an aluminium block, an aluminium angle plate, a heat-pipe or any other suitable heat conductor.

Without the intention to limit the scope of protection of the invention, but rather to simplify the description, the term power supply is used consecutively instead of the term electrical and/or electronical device unless otherwise mentioned.

With a power supply according to the invention, a very efficient heat dissipation can be achieved. Since the heat generating components are in good thermal contact with the casing of the power supply, the heat generated by the power supply can be effectively transferred to the casing. Furthermore, by providing an air duct within the casing, the surface for transferring the heat from the casing to the surrounding air can be increased. And finally, the fan produces a high air flow through the air duct that efficiently dissipates the heat from the air duct.

Another advantage is that the space requirements are low. The air duct in the double wall portion can be provided very space-efficiently. Furthermore, the additional costs for providing a double wall portion of the casing are significantly smaller than for providing an supplementary traditional heat sink.

Moreover, the invention enables very flexible designs because the shape and the dimensions of the air duct can be varied very easily and in a wide range.

For example, the cross sectional area or the shape of the cross section of the air duct can be varied. The air duct can have a closed cross section such as for example a rectangular, a circular or an oval cross section. In this case, all of the air transits the air duct. The air duct may also have holes where some of the air may escape from the air duct. The air duct can also have an open cross section such as for example a C-like or a U-like cross section. In this case, some of the air that enters the air duct, leaves the air duct through the open side of it and does not transit entirely through it.

As long as the casing is enough stable and sturdy, it could be made of any suitable material such as for example any synthetic material or metals. But in order to enhance the heat transfer from the heat generating component to the casing and further to the air, the casing is preferably made of a material with a high coefficient of thermal conductivity such as for example metals like copper or aluminium. The usage of aluminium is favoured because of its lower specific gravity and the lower manufacturing costs.

The electric and/or electronic circuit can be realised in any known manner. However, printed cirucit boards are commonly used and are therefore preferred to implement the circuit. Since the heat generating component is a part of the circuit, it is electrically connected to the printed circuit board in some way. For example, the component is mounted directly on the surface of the board or the component includes wires that are soldered to the circuit board. The component may also be connected to the circuit board by a flexible connection such as cable.

Since the shape of the casing is not critical for the realisation of the invention, almost any shape of the casing is possible. However, in order that a power supply according to the

invention can be applied in many different applications, the appropriate standards should be observed. That is why the shape of the casing is preferably cubical with the dimensions corresponding to the relevant standards of the particular application.

The casing can be of a one-piece or a multi-piece design. A one-piece design has the advantage that there is no need to assemble the casing, but it is more difficult to assemble the whole power supply, since most parts of the power supply are arranged within the casing. In a preferred embodiment of the invention, the casing includes multiple pieces, at least a bottom and a cover, where the printed circuit board is mounted on the bottom. The inner wall portion of the air duct is a part of the bottom and the outer wall portion of the air duct is a part of the cover.

To form the casing, the bottom and the cover are fitted together so that a good thermal contact between them is accomplished and so that the inner wall portion and the outer wall portion are arranged to form the air duct. Since the power supply can be assembled at least partially before the bottom and the cover are fitted together, it is less laborious to manufacture the whole power supply.

Additionally to the bottom and the cover, the casing may include further pieces, such as for example a separate front or rear panel.

There are many possibilities to assemble the bottom and the cover such as for example by means of rivets, nuts and bolts or screws and the like or by welding, soldering, bonding, gluing and the like. In a preferred embodiment of the invention the bottom and the cover are screwed, because screwing is a simple, fast and cost-efficient method for assembling two pieces of metal.

The screwing alone generates a good thermal contact between the bottom and the cover. To further improve the thermal conduction between bottom and cover, thermal paste can be applied between contacting parts of the bottom and the cover before they are fitted together.

The bottom of the casing includes a base plate and a side plate which are arranged such that they are perpendicular to each other having a common edge. The side plate of the

bottom is designated hereafter as the bottom side plate. The cover piece of the casing includes a top plate and a further side plate, hereafter designated as the cover side plate. The top plate and the cover side plate are also arranged perpendicular to each other and have a common edge.

While the bottom side plate forms the inner wall portion, the cover side plate forms the outer wall portion of the casing's double wall portion.

The printed circuit board is mounted on the bottom such that it is substantially parallel to the base plate and that one edge of the printed circuit board is in contact with the bottom side plate or is at least situated close to it. The heat generating component is mounted on the printed circuit board in the immediate vicinity of that edge such that the heat generating component is in contact with the bottom side plate or is positioned close to it. In order to have a good thermal contact the heat generating component can further be pressed against the bottom side plate by any suitable means such as for example bonding.

As outlined above, the casing is of substantially cubical shape and the cover side plate forms the outer wall portion of the double wall portion . In an advantageous embodiment of the invention, the cover side plate also forms an outer surface of the power supply's casing, particularly a lateral surface of the cubical casing. Therefore, the air duct is positioned along a lateral surface of the cubical casing. That is, the air duct leads from a front surface of the casing to the rear surface. The front surface includes at least one aperture where the air flow from the fan can enter the air duct. Similarly, the rear surface of the caing also includes at least one aperture such that the air flow can escape from the air duct.

Typically, the air flow through the air duct is always in the same direction, entering the air duct at an inlet, passing through it and quitting it at an outlet. The inlet is formed by the corresponding end regions of the bottom side plate and the cover side plate in the region of the front surface. The air flow through the air duct with straight end regions of these side plates may be sufficient for many applications. Other applications require increased cooling capabilities and therefore an increased air flow through the air duct. An increased air flow can be achieved by an inlet with a funnel-like shape. A simple and preferred way to

realise a funnel-like shape of the inlet is bending the end region of the bottom side plate to an inner side of the casing.

The fan that generates the air flow through the air duct is preferably arranged on the front surface of the cubical casing. It is arranged such that it covers the inlet of the air duct at least partially so that the air flow of the fan or a part of the air flow can directly enter the air duct.

It would also be possible to position the fan somewhere else and direct the air flow to the inlet of the air duct by supplementary means, but this would mean additional effort and hence additional costs.

To increase the cooling capabilities of the power supply even more, an additional heat sink is mounted within the air duct such that the air flow through the air duct also dissipates the heat from the additional heat sink. Here it is important that the additional heat sink is in good thermal contact with the double wall portion of the casing, that is either with one or more inner surfaces of the air duct. This ensures a good heat transfer from the casing to the additional heat sink.

As explained above, the invention can be applied in power supplies or other electrical and/or electronical devices where waste heat is generated. A preferred application of the invention are power supplies where the waste heat is generated by one or more power semiconductors, such as diodes, thyristors, transistors, triacs or other heat generating power semiconductors.

Since a typical power supply has more than one outer surface, it is advantageous to provide further air ducts, particularly a second air duct at another outer surface of the casing. For this purpose, the casing includes a second double wall portion with an inner wall portion and an outer wall portion that define a second air duct along the other surface of the casing. The air flow through the second air duct may be generated by the first fan or the power supply may include a second fan (or even further fans) to produce this second air flow. Since the second air duct acts as a second heat sink, more waste heat can be dissipated.

In the case of a cubical casing of the power supply, the second double wall portion is preferably located along the second lateral surface of the casing and a second fan is arranged at the same surface as the first fan such that the air flow from the second fan is directed through the second air duct.

Other advantageous embodiments and combinations of features come out from the detailed description below and the totality of the claims.

Brief Description of the Drawings

The drawings used to explain the embodiments show:

Fig. 1	A schematic cross section of a power supply according to the invention in a front view;
Fig. 2	the cross section of fig. 1 including two fans;
Fig. 3	a schematic cross section of the power supply of fig. 1 in a top view;
Fig. 4	a detailed view of the cross section of another power supply according to the invention;
Fig. 5a - Fig. 5f	detailed views of the cross section of the double wall portion of the power supply shown in fig. 1 in different implementations with an open air duct;
Fig. 6a - Fig. 6d	detailed views of the cross section of the double wall portion of the power supply shown in fig. 1 in different implementations with closed air duct;
Fig. 7a - Fig. 7b	detailed views of the cross section of the double wall portion of the power supply shown in fig. 1 in different implementations with an additional heat sink within the air duct;
Fig. 8a - Fig. 8b	detailed views of the cross section of the double wall portion of another embodiment of a power supply according to the invention;

Fig. 9 an assembled power supply according to the invention in a top view;

Fig. 10 the power supply of fig. 9 in a bottom view and

Fig. 11 the power supply of fig. 9 in a back view.

In the figures, the same components are given the same reference symbols.

Preferred Embodiments

Figure 1 shows a schematic illustration of a cross section of a power supply 8 according to the invention. The power supply 8 includes a casing with a bottom 2 and a cover 3 that are made of aluminium sheets. Although larger or smaller power supplies can be realised, the length of the power supply 8 is typically between 10 cm and 40 cm, the width between 4 cm and 25 cm and its height between 4 cm and 25 cm. While certain applications require thicker or thinner sheets, the thickness of the aluminium sheets varies typically between 0.5 mm and 3 mm. The bottom 2 includes a bottom plate 2.1 and two inner side plates 2.2 and the cover 3 includes a top plate 3.1 and two outer side plates 3.2. The bottom 2 is built such that it has a U-like shaped cross section, where the bottom plate 2.1 is the base of the U and the inner side plates 2.2 are the arms of the U. The cover 2 is also built such that it has a U-like shaped cross section, where the top plate 3.1 is the base of the U and the outer side plates 2.2 are the arms of the U.

The cover 3 is wider than the bottom 2. They can therefore be assembled by inserting the bottom 2 into the cover 3 and fitted together by suitable means so as to achieve a good thermal conduction between the bottom 2 and the cover 3. They are for example screwed (not shown in fig. 1). When fitted together, the inner side plates 2.2 of the bottom 2 and the outer side plates 3.2 of the cover 3 define two air ducts 4.

A printed circuit board PCB 1 is mounted on the bottom 2 such that it is substantially parallel to the bottom plate 2.1. Different components 6 are mounted on the PCB 1. These may be mechanical, electric, electronic or other components. The components can be positioned directly on the surface of the PCB 1 and soldered to corresponding soldering

pads or they can be equipped with one or more wires that are soldered into corresponding holes in the PCB 1. The components can also be differently fitted to the PCB 1 as long as the necessary electrical and mechanical connections are established.

Near the border of the PCB 1 in the vicinity of the inner side plates 2.2, heat generating components 5 are mounted. They are arranged such that they contact the inner side plates 2.2. Furthermore, they are tightly fitted to the inner side plates 2.2 so as to achieve a good thermal conduction between the heat generating components 5 and the inner side plates 2.2.

In order to allow a better understanding, the figures show a small gap between the bottom 2 and the cover 3 although they are tightly pressed together. The same applies to the illustration of the contact between the heat generating components 5 and the inner side plates 2.2.

In fig. 2, the same power supply 8 is shown as in fig. 1. The only difference is that fig. 2 shows to fans 7, the positions of which are indicated with dashed lines. The fans 7 produce an air flow (not shown) that runs perpendicular to the drawing plane, partially through the inside of the casing and partially through the air ducts 4.

Thanks to the good thermal conduction between the heat generating components 5 and the inner side plates 2.2 as well as between the bottom 2 and the cover 3, the waste heat generated by the heat generating components 5 is efficiently transferred to the inner side plates 2.2, to the top plate 3.1 and the outer side plates 3.2. With such an arrangement, the waste heat can be efficiently spread over an enlarged surface area of the bottom 2 and the cover 3 both on the inside and on the outside of the casing. This means that the waste heat can be efficiently dissipated to the air within the casing, on the outside of the casing and within the air ducts 4. Hence, the air flow produced by the fans 7 efficiently dissipates the heated air within the casing as well as within the air ducts 4.

Fig. 3 shows a cross section of the power supply 8 parallel to the bottom plate 2.1 in a top view. Here, the PCB 1 with the heat generating components 5 can be seen as well as the

inner side plates 2.2, the outer side plates 3.2 and the fans 7. The arrows 9 illustrate the air flow from the fans 7 and the arrows 9.1 designate the air flow through the air ducts 4.

Fig. 4 shows a detailed view of the cross section of another power supply according to the invention. Particularly, fig. 4 shows the inlet of an air duct 4. The inlet is formed by the front sections of the inner side plate 2.2 and the outer side plate 3.2. In this embodiment, the front section 10 of the inner side plate 2.2 is bent towards the inside of the casing such that the inlet has a funnel-like shape. As a result, more air is blown through the air duct 4 by the fan 7 as shown by the arrows 9.1.

In fig. 5, some schematic open cross sections of different implementations of the bottom 2 and the cover 3 to achieve good thermal conduction are illustrated. To simplify the drawings, neither the components 6 nor the heat generating components 5 are shown. In fig. 5a the upper edge 2.3 of the inner side plate 2.2 is orthogonally angled to an inner side of the casing such that it is parallel to the top plate 3.1. By means of a connection 11, for example a screw or a nut with corresponding bolt, that is positioned in the range of the angled upper edge 2.3, the bottom 2 and the cover 3 are fitted together such that the angled upper edge 2.3 is tightly pressed against the inner surface of the top plate 3.1.

In fig. 5b the upper edge 2.3 is orthogonally angled outwardly with respect to the casing of the power supply 8. The connection 11 corresponds to the connection 11 as shown in fig. 5a. In fig. 5c the upper edge 2.3 is angled twice such that it has a U-shape. Here, the screw or bolt of the connection 11 is arranged orthogonally to the inner side plate 2.2 and the outer side plate 3.2. By varying the width of the U of the upper edge 2.3, the distance between the inner side plate 2.2 and the outer side plate 3.2, that is the width of the air duct 4, can be varied.

In fig. 5d, the upper edge 2.3 of the inner side plate 2.2 is not angled but straight. In order to have the parallel surfaces that are necessary for a good thermal contact between bottom 2 and cover 3, a spacer 12 is inserted into the upper part of air duct 4. The connection 11 is arranged orthogonally to the inner side plate 2.2 and the outer side plate 3.2 right through the spacer 12. To ensure a good thermal conduction, the spacer 12 also is made of aluminium.

Fig. 5e shows an embodiment where the upper edge 2.3 of the inner side plate 2.2 is bent twice and has the shape of a Z such that its most upper part again is parallel to the outer side plate 3.2. In fig. 5f, it is not the inner side plate 2.2 that is bent but it is the corresponding portion 3.4 of the outer side plate 3.2 that is bent Z-like.

All embodiments of fig. 5 have a common feature, the air duct 4 is not closed but open.

In fig. 6, various embodiments of the power supply 8 are shown where the bottom 2 and the cover 3 define a closed or at least a partially closed air duct 4. To achieve this, either the lower edge 3.3 of the outer side plate 3.2 or the corresponding lower portion 2.3 of the inner side plate 2.2 are built correspondingly. In fig. 6a the lower edge 3.3 of the outer side plate 3.2 is bent Z-like and in fig. 6b it is bent U-like. As shown in fig. 6c, the air duct 4 can also be closed by a spacer 12 that is inserted into the lower part of the air duct 4. In fig. 6d the lower portion 2.4 of the inner side plate 2.2 is bent Z-like to realise the necessary distance between the inner side plate 2.2 and the outer side plate 3.2. To enhance the heat transfer from the bottom 2 to the cover 3, a second connection 11 can be provided at the lower end of the air duct 4.

In all of the embodiments shown, it is possible to vary the dimensions of the air duct 4 in a wide range by changing the shape of the bottom 2 and/or the cover 3. The dimensions and therewith also the cooling properties of the air duct 4 can be chosen such that the requirements of a particular application are met as good as possible.

As mentioned above, an additional heat sink can be inserted into the air duct 4 to further improve the heat dissipation. Fig. 7 shows two examples how this could be done. In fig. 7a a heat sink with a single base block 13 with two laterally extending fins 14 is shown. The connection 11 is positioned such that the base block 13, the inner side plate 2.2 and the outer site plate 3.2 are tightly pressed together. Thanks to the tight contact between the base block 13 and the inner side plate 2.2 as well as the outer site plate 3.2, the waste heat can be transferred to the fins 14 that are efficiently cooled by the high air flow trough the air duct 4. In the exemplary embodiment of fig. 7b the additional heat sink includes a base block 13 at the upper end of the air duct 4 and a base block 13 at the lower end of it,

both of them being connected by a fin 14. Naturally it is also possible to provide more base blocks 13 or fins 14 within the air duct 4.

It is not necessary that the heat generating component 5 is mounted on the PCB 1 such that it is in tight contact with the inner side plate 2.2. Generally, it is also possible that the heat generating component 5 is in thermal contact with any other inner surface of the power supplies casing. Fig. 8a shows an embodiment where the heat generating component is mounted on the lower surface of the PCB 1 such that it is in thermal contact with the bottom plate 2.1 of the bottom 2. The outer side plate 3.2 is formed such that it includes a lower portion 3.5 that is parallel to the bottom plate 2.1 and covers that area of the bottom plate 2.1 where the heat generating component 5 is positioned.

Fig. 8b shows a similar embodiment where the edge 3.3 of the lower portion 3.5 is bent Z-like to realise a closed air duct 4. The air duct 4 is separated into two single air ducts 4 by means of a spacer 12. Further it is to note that the heat generating component 5 is mounted on the upper surface of the PCB 1. In this case, a good thermal conduction between the PCB 1 and the bottom plate 2.1 has to be ensured.

It is understood that all of the embodiments shown in the figures, particularly each type of connection between bottom 2 and cover 3, can be combined with each other to realise further embodiments of the inventive power supply. Moreover, to enhance the heat transfer between the bottom 2 and the cover 3, thermal paste (not shown in the figures) can be applied on the contacting areas before fitting together the bottom 2 and the cover 3.

The figures 9, 10 and 11 show an assembled power supply 8 according to the invention in a top view (fig. 9), a bottom view (fig. 10) and a back view (fig. 11). Shown are the cover 3 with the top plate 3.1 and the outer side plates 3.2, the bottom 2 with the bottom plate 2.1 and the inner side plates 2.2, the fans 7 and the air ducts 4.

Furthermore, figures 9 and 10 show a front panel 15 with suitable ventilation apertures 17 for the fans 7. The front panel 15 can be built separately or it can be a part of the bottom 2 or the cover 3.

In the back view of the power supply 8 in fig. 11 a rear panel 16 is shown. It includes a plurality of ventilation apertures 17 as the outlets for the air that is directed through the casing. Typically, the rear panel includes connecting means such as plugs and the like (not shown) to connect the power supply 8 to the device that has to be supplied with power.

In summary, it is to be noted that the invention enables the manufacturing of electrical and/or electronical devices such as for example power supplies with highly improved cooling capabilities while only a minimum of extra space is required. Furthermore, the stability and sturdiness of the casing of the power supply can also be improved, since the bottom and the cover can be provided with additional contacting and fixation areas.